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THE IMPACT OF SURGICAL-SITE INFECTIONS FOLLOWING ORTHOPEDIC SURGERY AT A COMMUNITY HOSPITAL AND A UNIVERSITY HOSPITAL: ADVERSE QUALITY OF LIFE, EXCESS LENGTH OF STAY, AND EXTRA COST

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ABSTRACT

OBJECTIVE: To measure the impact of orthopedic surgical-site infections (SSIs) on quality of life, length of hospitalization, and cost.

DESIGN: A pairwise-matched (1:1) case–control study within a cohort.

SETTING: A tertiary-care university medical center and a community hospital.

PATIENTS: Cases of orthopedic SSIs were prospectively identified by infection control professionals. Matched controls were selected from the entire cohort of patients undergoing orthopedic surgery who did not have an SSI. Matching variables included type of surgical procedure, National Nosocomial Infections Surveillance risk index, age, date of surgery, and surgeon.

MAIN OUTCOME MEASURES: Quality of life, duration of postoperative hospital stay, frequency of hospital readmission, overall direct medical costs, and mortality rate.

RESULTS: Fifty-nine SSIs were identified. Each orthopedic SSI accounted for a median of 1 extra day of stay during the initial hospitalization ($P = .001$) and a median of 14 extra days of hospitalization during the follow-up period ($P = .0001$). Patients with SSI required more rehospitalizations (median, 2 vs 1; $P = .0001$) and more total surgical procedures (median, 2 vs 1; $P = .0001$). The median total direct cost of hospitalizations per infected patient was $24,344, compared with $6,636 per uninfected patient ($P = .0001$). Mortality rates were similar for cases and controls. Quality of life was adversely affected for patients with SSI. The largest decrements in scores on the Medical Outcome Study Short Form 36 questionnaire were seen in the physical functioning and role-physical domains.

CONCLUSIONS: Orthopedic SSIs prolong total hospital stays by a median of 2 weeks per patient, approximately double rehospitalization rates, and increase healthcare costs by more than 300%. Moreover, patients with orthopedic SSIs have substantially greater physical limitations and significant reductions in their health-related quality of life (*Infect Control Hosp Epidemiol* 2002;23:183-189).

It is estimated that more than 500,000 surgical-site infections (SSIs) occur each year in the United States, at a rate of 2.8 per 100 operations.[1] These SSIs constitute between one-fourth and one-third of all nosocomial infections.[2,3] Several studies have attempted to quantify the impact of SSI on the length and costs of hospitalization.[4-8] Length of hospitalization was the main outcome measured in these studies: SSI prolonged the length of hospitalization by 7 to 19.5 days. The authors of one of these studies estimated that the mean additional cost per patient hospitalization was $4,500 for patients hospitalized in the early 1990s.[8] The authors of a more recent study found similar results.[9]

Most studies addressing the overall impact of SSI have been conducted at tertiary-care referral centers. This referral bias may have led to overestimates of the impact of infections on the quality of life because large teaching centers are likely to care for more complex cases. Moreover, the authors of most outcome studies cited above have included patients who underwent a variety of cardiovascular, surgical, gastrointestinal, and orthopedic procedures. Thus, the effect of infection on patients with specific types of SSIs (eg, orthopedic infections) is difficult to discern from the existing literature.

We conducted a study from an institutional perspective of patients from both a tertiary-care referral center and a community hospital to measure the impact of orthopedic SSI on (1) length of stay; (2) incidence of readmission; (3) costs attributable to SSI; and (4) quality of life.

METHODS

Setting

Our study included patients from Duke University Medical Center (DUMC), Durham, North Carolina, a 1,000-bed teaching center providing primary-, secondary-, and tertiary-care to residents of Durham and the southeastern United States; and Durham Regional Hospital (DRH), a 450-bed community hospital that has a teaching affiliation with DUMC. Each year, approximately 4,300

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inpatients undergo orthopedic surgery at DUMC and approximately 1,750 inpatients undergo orthopedic surgery at DRH.

Approval for this study was obtained from the institutional review boards at both hospitals.

Definitions of Patient Selection and Case Identification

SSI. SSIs were defined using Centers for Disease Control and Prevention (CDC) National Nosocomial Infections Surveillance (NNIS) criteria.[10] SSIs were categorized as superficial incisional, deep incisional, or organ/space infections. Incisional SSIs were those that occurred within 30 days following surgery. If surgery involved placement of an implant, any deep incisional or organ/space SSI that occurred within 1 year following surgery was included in the study.

Case-Patients. A case-patient was defined as any patient who had an SSI following an inpatient surgical procedure. Case-patients identified at DUMC had their original operative procedure between January 1 and December 31, 1997. Case-patients identified at DRH had their original operative procedure between January 1, 1997, and June 1, 1998. If a patient had more than one episode of infection, only the first episode was considered.

Case Identification. Infection control professionals at both institutions performed prospective inpatient surveillance for SSI on all hospital wards, as well as laboratory-based surveillance. Data were collected for each case identified through surveillance for SSI. A few additional cases were identified by inpatient case managers who reported suspected cases of SSI to the infection control programs at both hospitals. Orthopedic surgeons at DRH reported additional cases of postdischarge SSI in response to regularly mailed lists of recent surgical patients using a system that has been previously described.[9] No formal postdischarge surveillance was in place at DUMC during the study period. At both hospitals, postdischarge infections that resulted in readmission were identified by the inpatient surveillance system.

Finally, to ensure complete identification of cases, the operating room registries of both hospitals were searched for the years 1997 to 1998 using International Classification of Diseases, 9th revision, procedure codes that included keywords such as "debridement," "infection," or "infected."

Control-Patients. For each case-patient, a matched control was selected from a database containing information on all inpatients who had undergone orthopedic surgery during the study period. Variables used for matching included type of operative procedure, NNIS risk index,[11,12] age within 5 years, date of surgery within the same year, and surgeon.[9]

Selection for the best possible match using the preceding criteria was performed in a stepwise fashion. If more than one equivalent potential control existed, a single individual was randomly chosen using a random numbers chart. If no control-patient met the above matching criteria, the corresponding case was rejected from further analysis.

Data Collection

Patient Characteristics. For each case-patient and his or her matched control, data including date of birth, gender, race, dates of any hospitalizations during the follow-up period, residence in a nursing home or rehabilitation center, and use of home healthcare services were collected by review of each patient's medical record. The quality-of-life questionnaire was administered by telephone interview. Following the questionnaire, patients were asked to provide information regarding the highest level of education completed and preoperative and postoperative employment status.

Hospitalization Data. For each matched pair, data were collected regarding the length of the initial (surgical) hospitalization, the need for hospital care within the follow-up period of 1 year after the identification of an SSI, the length of each subsequent hospitalization, whether additional operations were performed, death during initial postoperative hospitalization, or death during the 1-year follow-up period. Excess length of hospitalization attributable to SSI was defined as the median difference in the total number of days of hospitalization during the 1-year follow-up period between matched pairs.

Cost Data. Due to changes in the accounting methods used at DRH during the time period of the study, accurate assessments of charges or costs could not be obtained; thus, cost data were available only for patients hospitalized at DUMC.

For DUMC patients, total direct costs were obtained from the hospital business office for each patient's initial hospitalization and for any subsequent hospitalizations during the follow-up period. These total direct costs represent the sum of costs required to provide the healthcare services and medications that were directly related to each patient's diagnosis and care as previously described,[9,13] and include variable-direct costs (the costs of the services and materials directly consumed by each patient during each hospitalization, such as the costs of implants, anesthesia, operating and hospital rooms, physicians, physical therapy, laboratory, and medications) and fixed-direct costs (the costs of services and materials, such as salaries and electrical and institutional maintenance costs, that are consumed by all patients during hospitalization, regardless of the reason for hospitalization). Total direct costs do not include indirect costs, which are costs that are not specifically attributed to, or identified with, an individual patient or procedure, such as the costs for laundry and housekeeping. Excess total direct costs attributable to the SSI were defined as the median difference in overall cost between matched pairs. Outpatient cost data were not included in this study.

Medical Outcome Study Short Form 36 Questionnaire (SF-36) Data. Case-patients and their matched controls were interviewed by telephone approximately 1 year after the detection of the SSI in the case-patient

and 1 year after the time of initial surgery in the matched control-patient. After obtaining verbal informed consent, one investigator (JDW) conducted the interviews between February and June 1999. Quality of life was measured on the short form of a questionnaire containing 36 items (SF-36). The SF-36 is a patient-based health outcome assessment scale measuring 8 elements of general well-being, which has been validated extensively as a reliable tool and has been used previously among orthopedic patients.[14-19]

Eight scores (physical functioning, physical role functioning, emotional role functioning, social functioning, bodily pain, mental health, vitality, and general perception of health) are tabulated from individual responses. Scores are assessed on a scale ranging from 0 (for poorest) to 100 (for best); differences of 3 to 5 points are considered important.[19] Low numeric scores reflect a perception of poor health, loss of function, and presence of pain. High numeric scores reflect a perception of good health, no functional deficits, and absence of pain.[20]

Data Management and Statistical Analysis

Differences and similarities in characteristics of cases and controls were compared using the chi-square test. Both the lengths of stay and the costs were compared among cases and controls who survived (survivor-matched pairs). Point estimates and interquartile ranges for median differences in length of hospitalization and direct costs between cases and their matched controls were compared using the Wilcoxon signed rank test. Measures of quality of life that were multidimensional were analyzed using a multivariate analysis of variance. A two-sided *P* value of .05 was considered significant for all statistical tests. Data were maintained and analyzed using Access (Microsoft, Redmond, WA), Epi Info (CDC, Atlanta, GA), and SAS statistical software (SAS Institute, Cary, NC).

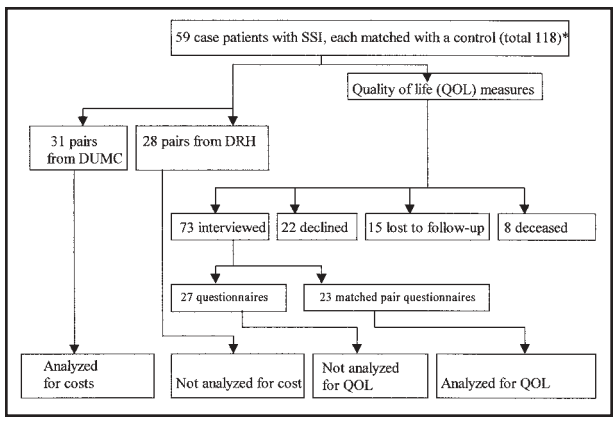

FIGURE. Study profile of cases and controls indicating outcome measures and patients lost to follow-up. * = all analyzed for length of stay and readmission; SSI = surgical-site infection; DUMC = Duke University Medical Center; DRH = Durham Regional Hospital.

RESULTS

We identified 59 case-patients who had SSIs following orthopedic surgery, and each was matched with a suitable control. The study group consisted of 31 matched pairs of patients at DUMC and 28 matched pairs of patients with SSIs from DRH (Figure). Eleven (19%) of 59 patient pairs underwent joint replacement; among the remaining pairs, a wide variety of orthopedic procedures were performed (Table 1). Matched pairs had the same surgeon in 81% of cases, the same operative procedure in 92% of cases, and surgery within 6 months of each other in 95% of cases (Table 2).

Admissions, Days of Hospitalization, Number of Operations, and Mortality

For infected patients, the median length of initial hospitalization was 6 days, compared with 5 days for unin-

TABLE 1
OPERATIVE PROCEDURES AND TOTAL NUMBER OF PATIENTS

	University			Community			
	Cases	Controls	No. of Matches	Cases	Controls	No. of Matches	Total
Type of operation			29			25	
ORIF				3	5	3	8
Fracture	5	6	5				11
Fusion	4	4	4	8	7	7	23
Hip arthroplasty	3	3	3	3	2	2	11
Knee arthroplasty	3	3	3	2	2	2	10
Other JPRO				1	1	1	2
Laminectomy	1	1	1	1	2	1	5
Amputation	1	1	1	3	3	3	8
Skin graft	1	1	1				2
Unknown	1	1	1				2
OMS*	12	11	11	7	6	6	36

ORIF = open reduction and internal fixation; Other JPRO = other joint prosthesis; OMS = other musculoskeletal.
*OMS included tumor resection with muscle flap (3), irrigation and debridement (3), bone grafting (2), osteotomy (2), leg resection (2), bilateral knee disarticulation (1), distal radius cuff with bone graft (1), osteoid osteoma excision (1), knee sequestrectomy (1), sacroiliac joint fusion (1), hip fusion (1), lunate capsulodesis (1), finger arthroplasty (1), medial malleolus reconstruction (1), ganglion excision (1), and application of external fixator (1).

TABLE 2
RESULTS OF CASE–CONTROL MATCHING CRITERIA

	University	Community	Total
No.	31	28	59
Operative procedure	29	25	54 (92%)
NNIS risk index	27	24	51 (86%)
Age within 5 y	27	16	43 (73%)
Age within 10 y	30	23	53 (90%)
Surgery dates within 6 mo	29	27	56 (95%)
Surgeon	21	27	48 (81%)

NNIS = National Nosocomial Infections Surveillance.

TABLE 3
RESULTS OF COSTS ANALYSIS AT DUKE UNIVERSITY MEDICAL CENTER

	Case Median (IQR)	Control Median (IQR)	*P*
No.	31	31	
Variable-direct costs	$21,627* ($12,406, $30,360)	$5,968 ($3,794, $7,642)	.0001
Fixed-direct costs	$2,717 ($1,545, $4,354)	$668 ($476, $873)	.0001
Indirect costs	$14,720 ($8,446, $27,069)	$3,766 ($2,667, $5,160)	.0001
Total costs	$38,640 ($22,497, $63,358)	$10,671 ($7,090, $12,529)	.0001

IQR = interquartile range.
*Values are expressed as median and IQR and were calculated using the Wilcoxon signed rank test comparing surgical-site infection cases and controls.

TABLE 4
RESULTS OF THE SHORT FORM 36 (SF-36) QUESTIONNAIRE

SF-36 Scales: Health Concepts	Cases	Controls	*P*
No.	23	23	
Physical functioning	40 ± 31*	60 ± 29	.014
Role-physical	36 ± 37	62 ± 41	.022
Bodily pain	42 ± 24	54 ± 27	.16
General health perceptions	51 ± 25	59 ± 26	.21
Vitality	53 ± 8	55 ± 8	.25
Social functioning	65 ± 29	74 ± 27	.35
Role-emotional	77 ± 38	78 ± 36	.86
Mental health	53 ± 15	48 ± 18	.42

*Values are expressed as mean ± standard deviation; higher scores denote better health-related quality of life.

fected control patients. The median excess length of initial hospitalization attributable to SSI was 1 day (P = .001). Patients with SSI required more total hospitalizations (median, 2 vs 1 hospitalizations; P = .0001) and more surgical procedures (median, 2 vs 1 operations; P = .0001). As a result, orthopedic patients with SSI had an excess total length of hospitalization of 14 days (19 vs 5 days; P = .0001).

Length of hospitalization, number of admissions, number of operations, and total number of days of hospitalization were similar for patients at DUMC and DRH (data not shown). Five infected patients and 3 uninfected patients were known to have died during the follow-up period (5 vs 3 deaths; P = .71).

Costs of Hospitalizations

Infected patients had greater median variable-direct, fixed-direct, and total direct costs than their matched controls (Table 3). The median total direct cost of hospitalization for infected patients was $24,344, compared with $6,636 for uninfected patients (P = .0001). The total cost of all patients from DUMC with SSIs was $1,197,840, compared with $330,801 for uninfected patients. Thus, the total extra cost attributable to orthopedic SSIs at DUMC during the 1-year study period was $867,039.

Quality of Life

Of the 118 study patients, 8 were known to have died during the follow-up period. Twenty-two (20%) of the remaining 110 patients were contacted and declined to participate in the questionnaire. Fifteen patients (13%) could not be located. Therefore, 73 (62%) of the original 118 patients consented to participate in the SF-36 questionnaire, 37 patients at DUMC and 36 at DRH. Forty-six (63%) of these 73 questionnaires could be analyzed in a matched-pair analysis (Figure).

Reductions in SF-36 scores that exceeded the minimum clinically meaningful threshold difference of 5 points were observed in 5 domains (Table 4). The greatest differences between matched pairs were observed in physical functioning and role-physical domains. Smaller but clinically meaningful reductions were observed in the bodily pain, general health, and social functioning domains. Unmatched analysis of all 73 respondents provided similar domain scores (data not shown).

DISCUSSION

The CDC has estimated that more than 18 million patients undergo surgery in U.S. hospitals each year.[9] Although national figures are not obtainable, the local experience at our two hospitals illustrates that orthopedic procedures account for an average of 25% (18% at DUMC and 32% at DRH) of surgeries performed each year. Published rates of SSI following orthopedic surgery range from 0.7% for low-risk patients undergoing hip replacement to as high as 7.9% for high-risk patients undergoing spinal fusion.[21] Therefore, somewhere between 31,500 and 355,500 patients each year have SSIs following orthopedic surgery.

The findings of our study suggest that the development of SSI following orthopedic surgery doubles a

patient's risk of readmission to the hospital during the next 12 months and more than triples the total direct cost of hospitalization. The total annual excess direct cost for just 30 patients with SSI at DUMC was nearly $1 million. Clearly, even a small number of SSIs can result in substantial economic costs.

We believe our study is unique in its focus on orthopedic patients, its inclusion of patients from both a community and a university hospital, its use of strict matching criteria, and its extended follow-up period. Most prior studies on the cost of infections following orthopedic surgery have not used matched controls for patients who had SSI.[22,23] The use of an unmatched control group can introduce considerable bias because the groups may not be similar enough regarding characteristics that may cloud or confound the conclusions. Most studies of the impact of SSI include patients who have undergone a broad range of surgical procedures. Because orthopedic infections can develop later after surgery, especially in the case of implants, we limited our focus to patients who had undergone orthopedic procedures only, and extended the study period to include the 12 months following surgery. In this way, we were able to demonstrate that although SSI appeared to prolong the initial hospitalization by only 1 day, the excess hospitalization attributable to SSI in the year following orthopedic surgery was 14 days. Not surprisingly, the additional inpatient costs for such infections were also substantial.

Our study supports the findings of other published reports that patients who have SSI following orthopedic procedures incur enormous excess costs. For example, in a study by Sculco, the average cost of care for prosthesis removal, 6 weeks of parenteral antibiotics, and prosthesis reimplantation was approximately $50,000 per patient.[24] In a retrospective study by Hebert et al. using unmatched controls, the average hospital charge for an infected knee replacement was $84,000.[23] This estimate included 32 additional days of hospitalization and an average of 3 additional orthopedic procedures. Calderone et al. retrospectively studied patients who had wound infections following spinal surgery and compared them with unmatched controls who underwent lumbar fusion.[22] Patients undergoing lower back fusion who had infectious complications were hospitalized for an additional 59 days with an average total cost of treatment equaling $100,666 per patient. Hospital charges such as room and board, pharmacy, and laboratory costs accounted for the larger percentage of this cost. In addition, outpatient antibiotic costs accounted for an additional $8,000 to $13,500 per case and the cost of additional laboratory tests ranged as high as $10,000 per case.[22]

In comparison, during our study period, the total extra cost attributable to orthopedic SSIs was $867,039 ($27,969 per patient). Although our attributable cost is lower than those reported by others, we believe that our use of matched controls and costs rather than charges allowed us to more accurately measure the true inpatient costs of SSI. Also, remarkable changes have occurred during the past 4 to 5 years in access to complex outpatient and home care; thus, the shorter lengths of postoperative hospitalizations observed in both cases and controls undergoing orthopedic surgery in our study and the lower inpatient costs may reflect current pressures to limit the length of hospital stay and better access to outpatient services such as intravenous antibiotic therapy, skilled nursing, and physical therapy. Because we were unable to measure the costs of such outpatient services, our study clearly underestimates the overall costs associated with caring for a patient with an SSI.

Most U.S. hospitals are now reimbursed at a flat or capitated rate for specific illnesses and surgical procedures, and in some cases (eg, in uninsured patients) no compensation is received. Thus, an SSI is likely to result in uncompensated costs for additional surgical procedures and readmissions. Our data document that these costs are huge and the potential cost savings if such infections can be prevented are also huge. For example, a hospital in which 5,000 inpatient orthopedic surgical procedures are performed each year could save $350,000 per year in direct hospital costs by establishing programs that reduce its infection rate from 2% to 1%. Such a program might simply ensure the proper use of preoperative prophylactic antibiotics and benefit from cost savings by reducing subsequent infections.[25]

Few studies of the outcomes of SSI attempt to quantitate the impact of such infections on the patient's quality of life. Because we believe that such easily measurable outcomes as length of hospitalization and directs costs only begin to capture the degree of patient suffering that accompanies an infection such as a prosthetic joint infection, we extended our outcome measures to include a quality-of-life assessment.

Disease-specific health status questionnaires have been used extensively to evaluate outcomes in patients undergoing joint arthroplasty.[26] Ordinarily, after successful joint replacement, the improvements in physical function are substantial for patients with arthritis.[27] Our patients with SSI had substantial reductions in their quality-of-life measures 1 year after their initial surgery, compared with controls. These results are similar to those reported by authors of several prior studies that assessed the impact of SSI on the quality of life after orthopedic surgical procedures.[28-31] Only one prior report, which used different quality-of-life measurement tools, failed to show an impact of SSI on quality-of-life outcomes in patients with SSI following orthopedic surgery.[28]

We believe the SF-36 form that we used may be the best available tool for measuring quality of life in this setting. Generic health-related quality-of-life instruments such as the Sickness Impact Profile (SIP) and the SF-36 have been used to assess the outcomes for a variety of orthopedic procedures.[28-31] The SF-36 contains fewer questions than the SIP and takes less time to complete, and its validity has been illustrated in prior studies evaluating outcomes of patients undergoing orthopedic surgery.[14,20] In studies comparing the SF-36 questionnaire with the SIP among patients undergoing hip arthroplasty, the SF-36 was better

able to discriminate between patients with relatively good physical performance at 3 months regarding their ability to work, play sports, or garden.[14] Unfortunately, even the best validated questionnaires cannot measure the full human impact of an impairment resulting from an SSI.

Several limitations are inherent in our study. First, although our methods resulted in closely matched cases and controls, a wide variety of orthopedic surgical procedures were represented in the study such that matched pairs did not always have the same procedure. Some of these procedures (eg, the "other musculoskeletal" category in Table 1) are uncommon or relatively minor operations. Unfortunately, to collect a comparable cohort of joint replacement infections alone for analysis would be impossible during only a few years.

The other limitations of this study are the number of patients lost to follow-up and possible underestimations of the cost of SSI. Twenty percent of the patients who were contacted declined to participate in the SF-36 questionnaire, 13% of the patients could not be located 1 year after surgery, and an additional 7% of patients died during the follow-up period. All of these "missing cases" may have introduced a selection bias to our results. For example, it is possible that the patients who declined to participate in the questionnaire may have had more or less functional impairment or complications than the patients who agreed to participate.

In addition, because we were unable to contact all the study patients, it is possible that we failed to identify hospitalizations that occurred outside of the two study hospitals. Also, although our study allowed us to estimate excess hospital costs and stays associated with nosocomial SSIs, we did not use additional methods such as the Appropriateness Evaluation Protocol that uses explicit criteria to assign hospital days as noninfection related or infection related.[32,33] This may have led us to either underestimate the rate of hospital readmission, and the extra costs attributable to SSI, or wrongly assign hospital days as infection related.

Our study may also have underestimated the impact of SSI for other reasons. Our follow-up of 1 year following the recognition of infection, although longer than that used in most other studies, may have been too short for some of our patients. For example, patients who have infections after prosthetic joint replacement or spinal surgery may require multiple readmissions during several years after the onset of infection. In one study, the infection rate after apparently successful revision for an infected hip replacement was 10% at 3 years and 26% at 10 years.[34]

Our inability to measure the cost of outpatient care for our study patients certainly led us to underestimate the total costs associated with SSI following orthopedic surgery. These costs, which would include the cost of administration of outpatient antibiotics, home health care and physical therapy, clinic visits, and laboratory tests, are likely to be substantial in many patients with SSI. In one study, an average of 4.6 outpatient encounters occurred within the first 30 days of surgery alone for each patient who had an SSI.[35] Also, the cost of home therapy is estimated to have escalated during the past decade.[36]

In addition, none of our estimates come close to measuring the total financial and personal impact of SSI on patients, which would include such measures as the attributable lost income among infected patients.[22] In fact, the lost productivity imparted on society and on the individual by disability following surgery that was intended to improve function and activity may not be measurable.

Previous estimates of the financial impact of nosocomial infections were derived from studies conducted in the past decade, before the current changes in the healthcare system. Our study provides a glimpse, and probably an underestimate, of the impact that SSIs following orthopedic surgery have on patients' quality of life and on the costs to patients and the healthcare system. Future studies that examine the cost and morbidity of SSI should use matched controls and appropriate time periods of follow-up and should measure inpatient and outpatient costs and functional status. Such studies will require large databases and likely will require collaboration between hospitals.

REFERENCES

1. Jarvis WR. Selected aspects of the socioeconomic impact of nosocomial infections: morbidity, mortality, cost, and prevention. *Infect Control Hosp Epidemiol* 1996;17:552-557.
2. Haley RW, Culver DH, White JW, Morgan WM, Emori TG. The nationwide nosocomial infection rate: a new need for vital statistics. *Am J Epidemiol* 1985;121:159-167.
3. Horan TC, Culver DH, Gaynes RP, Jarvis WR, Edwards JR, Reid CR. Nosocomial infections in surgical patients in the United States, January 1986–June 1992. *Infect Control Hosp Epidemiol* 1993;14:73-80.
4. Green JW, Wenzel RP. Postoperative wound infection: a controlled study of the increased duration of hospital stay and direct cost of hospitalization. *Ann Surg* 1977;185:264-268.
5. Brachman PS, Dan BB, Haley RW, Hooton TM, Garner JS, Allen JR. Nosocomial surgical infections: incidence and cost. *Surg Clin North Am* 1980;60:15-25.
6. Scheckler WE. Nosocomial infections in a community hospital, 1972 through 1976. *Arch Intern Med* 1978;138:1792-1794.
7. Taylor GD, Kirkland TA, McKenzie MM, Sutherland B, Weins RM. The effect of surgical wound infection on postoperative hospital stay. *Can J Surg* 1995;38:149-153.
8. Vegas AA, Jodra VM, Garcia ML. Nosocomial infection in surgery wards: a controlled study of increased duration of hospital stays and direct cost of hospitalization. *Eur J Epidemiol* 1993;9:504-510.
9. Kirkland KB, Briggs JP, Trivette SL, Wilkinson WE, Sexton DJ. The impact of surgical-site infections in the 1990s: attributable mortality, excess length of hospitalization, and extra costs. *Infect Control Hosp Epidemiol* 1999;20:725-730.
10. Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG. CDC definitions of nosocomial surgical site infection, 1992: a modification of the CDC definitions of surgical wound infections. *Infect Control Hosp Epidemiol* 1992;13:606-608.
11. Culver DH, Horan TC, Gaynes RP, et al. Surgical wound infection rates by wound class, operative procedure, and patient risk index. *Am J Med* 1991;91(suppl 3B):152S-157S.
12. Delgado-Rodriguez M, Sillero-Arenas M, Medina-Cuadros M, Martinez-Gallego G. Nosocomial infections in surgical patients: comparison of two measures of intrinsic patient risk. *Infect Control Hosp Epidemiol* 1997;18:19-23.
13. Abramson MA, Sexton DJ. Nosocomial methicillin-resistant and methicillin-susceptible *Staphylococcus aureus* primary bacteremia: at what costs? *Infect Control Hosp Epidemiol* 1999;20:408-411.
14. Stucki G, Liang MH, Phillips C, Katz JN. The Short Form-36 is preferable to the SIP as a generic health status measure in patients undergoing elective total hip arthroplasty. *Arthritis Care and Research* 1995;8:174-181.
15. Ware JE, Sherbourne CD. The MOS 36-item short form health survey (SF-36): I. Conceptual framework and item selection. *Med Care* 1992;30:473-483.

16. Stewart AL, Greenfield S, Hays RD, et al. Functional status and well-being of patients with chronic conditions: results from the Medical Outcomes Study. *JAMA* 1989;262:907-913.
17. McHorney CA, Ware JE, Raczek AE. The MOS 36-item short-form health survey (SF-36): II. Psychometric and clinical tests of validity in measuring physical and mental health constructs. *Med Care* 1993; 31:247-263.
18. McHorney CA, Ware JE, Rogers W, Raczek AE, Lu JF. The validity and relative precision of MOS short- and long-form health status scales and Dartmouth COOP charts: results from the Medical Outcomes Study. *Med Care* 1992;30:(suppl 5):MS253-MS265.
19. Ware JE, Snow KK, Kosinski M, Gandek B. *SF-36 Health Survey: Manual and Interpretation Guide.* Boston: The Health Institute; 1993.
20. Kiebzak GM, Vain PA, Gregory AM, Mokris JG, Mauerhan DR. SF-36 General Health Status Survey to determine patient satisfaction at short-term follow-up after total hip and knee arthroplasty. *J South Orthop Assoc* 1997;6:169-172.
21. 1996 National Nosocomial Infections Surveillance System (NNIS) Conference for Hospitals Participating in the National Infections Surveillance. *SSI Rates, by Operative Procedure and Risk Index Category, October 1986–July 1996.* Atlanta, GA: Centers for Disease Control and Prevention; 1996.
22. Calderone RR, Garland DE, Capen DA, Oster H. Cost of medical care for postoperative spinal infections. *Orthop Clin North Am* 1996;27:171-182.
23. Hebert CK, Williams RE, Levy RS, Barrack RL. Cost of treating an infected total knee replacement. *Clin Orthop* 1996;331:140-145.
24. Sculco TP. The economic impact of infected joint arthroplasty. *Orthopedics* 1995;18:871-873.
25. Classen DC, Evans RS, Pestotnik SL, Horn SD, Menlove RL, Burke JP. The timing of prophylactic administration of antibiotics and the risk of surgical-wound infection. *N Engl J Med* 1992;326:281-286.
26. Kreibich DN, Vaz M, Bourne RB, et al. What is the best way of assessing outcome after total knee replacement? *Clin Orthop* 1996;331:221-225.
27. McGuigan FX, Hozack WJ, Moriarty L, Eng K, Rothman RH. Predicting quality-of-life outcomes following total joint arthroplasty: limitations of the SF-36 health status questionnaire. *Journal of Arthroplasty* 1995;10:742-747.
28. Calderone RR, Thomas JC Jr, Haye W, Abeles D. Outcome assessment in spinal infections. *Orthop Clin North Am* 1996;27:201-205.
29. Kantz ME, Harris WJ, Levitsky K, Ware JE, Davis AR. Methods for assessing condition-specific and generic functional status outcomes after knee replacement. *Med Care* 1992;30(suppl 5):MS240-MS252.
30. Liang MH, Larson MG, Cullen KE, Schwartz JA. Comparative measurement of efficiency and sensitivity of five health status instruments for arthritis research. *Arthritis Rheum* 1985;28:542-547.
31. Bombardier C, Melfi CA, Paul J, et al. Comparison of a generic and disease-specific measure of pain and physical function after knee replacement surgery. *Med Care* 1995;33:AS131-AS144.
32. Gertman PM, Restuccia JD. The appropriateness evaluation protocol: a technique for assessing unnecessary days of hospital care. *Med Care* 1981;19:855-871.
33. Wakefield DS, Pfaller MA, Hammons GT, Massanari RM. The use of the appropriateness evaluation protocol for estimating the incremental costs associated with nosocomial infections. *Med Care* 1987;25:481-488.
34. Went P, Krismer M, Frischhut B. Recurrence of infection after revision of infected hip arthroplasties. *J Bone Joint Surg* 1995;77:307-309.
35. Holtz TH, Wenzel RP. Postdischarge surveillance for nosocomial wound infection: a brief review and commentary. *Am J Infect Control* 1992; 20:206-213.
36. Jarvis WR. Selected aspects of the socioeconomic impact of nosocomial infections: morbidity, mortality, cost, and prevention. *Infect Control Hosp Epidemiol* 1996;17:552-557.